The Standard Model Prediction for the ν_τ Charged-Current Cross Section

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Introduction

- For Standard Model prediction, must know which region
  - Deep Inelastic Scattering - treat quarks as essentially free particles
  - Not Deep Inelastic Scattering - this would put the region between DIS and resonance production - not sure how to calculate this prediction

Check the Region

- If $Q^2 \geq 1$ (GeV)^2 and $W \geq 1$ GeV, the region is DIS, where:

$$Q^2 = -q^2 = -(k_{\nu_\tau} - k'_\tau)^2 \qquad (1)$$

where k_{ν_τ} is the four-momentum of the ν_τ and k'_τ is the four-momentum of the τ lepton.

and

$$W = (P_{\mathrm{N}} \cdot q) = P_{\mathrm{N}}^2 + q^2 + 2P \cdot q \qquad (2)$$

where P_{N} is the four-momentum of the nucleon and q is defined above.

Using the fact that $P^2 = M_{\mathsf{N}}^2$, $q^2 = -Q^2$ and $P \cdot q = 2M_{\mathsf{N}} \cdot \nu$ where $\nu = (E_\nu - E_\tau)$:

$$W = (P_n \cdot q) = M_n^2 + 2M_{\mathsf{N}} \cdot \nu - Q^2 \qquad (3)$$

First I must calculate Q^2. To calculate Q^2, put it in terms of quantities we can measure:

$$(k_{\nu_\tau} - k'_\tau)^2 = k_{\nu_\tau}^2 + k'^2_\tau - 2(k_{\nu_\tau} \cdot k'_\tau) \qquad (4)$$

where

$$k_{\nu_\tau} \cdot k'_\tau = E_{\nu_\tau}(E_\tau - p_\tau \cos\theta) \qquad (5)$$

Then

$$Q^2 = m_\tau - 2(E_{\nu_\tau}(E_\tau - p_\tau \cos\theta)) \qquad (6)$$

So we need an estimate of the tau neutrino's energy

Estimating Energy of ν_τ

E_{ν_τ} is estimated using p_τ, the angle of the tau wrt the neutrino, θ, and the vector sum angle of the other tracks wrt to the neutrino, ϕ, and conservation of momentum.

The z-component of momentum is conserved:

$$p_{\nu_\tau} = p_\tau \cos\theta + p_W \cos\phi \tag{7}$$

and the transverse component is conserved:

$$0 = p_\tau \sin\theta - p_W \sin\phi \tag{8}$$

First solve for p_W:

$$p_\tau \sin\theta = p_W \sin\phi \tag{9}$$

$$p_W = \frac{p_\tau \sin\theta}{\sin\phi} \tag{10}$$

Then

$$p_{\nu_\tau} = p_\tau \cos\theta + \frac{p_\tau \sin\theta}{\sin\phi} \cos\phi \tag{11}$$

$$p_{\nu_\tau} = p_\tau \cos\theta + p_\tau \frac{\sin\theta}{\tan\phi} = E_{\nu_\tau} \tag{12}$$

Conclusions

- From the data for each tau candidate, p_T and $\sin\theta$ are measured. $\sin\phi$ can be calculated using the angles of the non-tau tracks.

- Currently I am gathering this data. I will have results for next meeting.